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Key Technologies for the Development of Fossil Fuels in the 21st Century

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Key Technologies for the Development of Fossil Fuels in the 21st Century*

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As the world faces growing economic and environmental challenges, the energy mix that fuels the global economy is undergoing rapid change. Yet how this change will evolve in the future is uncertain. What will be the sources of primary energy in twenty years? In fifty years? In different regions of the globe? How will this energy be utilized? Fossil energy currently supplies about ninety percent of the world's primary energy. In Japan this number is closer to eighty percent. It is clear that fossil energy will be a major supplier of global energy for some time to come, but what is not clear is the types of fossil energy and how it will be utilized.

The degree to which the abundant supplies of fossil energy, especially coal, will continue to play a major role will depend on whether technology will provide safe, clean and affordable fuel for electricity and transportation. Technology will not only assist in finding more fossil energy in varying regions of the globe but, most importantly, will play a strong role in efficient utilization and in determining the cost of delivering that energy.

Several important questions will have to be answered:

- Will cost effective technologies be found to burn coal more cleanly? Can this be done with drastically reduced or no emitted carbon?
- Can enough oil be found outside the Middle East to ensure more adequate and secure supplies to fuel the transportation and industrial needs?
- Will the transportation sector, so heavily dependent on oil, be fueled on another source?
- Can enough natural gas be assured from enough secure places to ensure investment in the utilization of this lowest-carbon fossil fuel?
- What will these options cost in research and in the price of energy?

The answers to these and other questions challenge leaders and researchers in the fossil energy industry.

A World Energy Council (WEC) study of those technologies that might be key sheds some light on what might happen in terms of a wide range of possible scenarios. Also

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on what might be necessary in expenditure, time, and policies to help bring these technologies to market. This study should be helpful to energy executives in planning for future technologies, either as new ventures or as competition for existing technologies.

The emphasis in this ongoing study is on what is possible from today's vantage, not what will happen—actual developments are unpredictable and it is, of course, impossible to foresee the course of actual technology development or economic growth. Nevertheless, it is possible to look at what could happen in a number of scenarios using 1) knowledge about current technologies and 2) their projected development, investment costs, and likely time to commercialization based on historical energy technology development. A comprehensive set of possible technologies was available from the WEC in conjunction with the International Institute for Applied Systems Analysis (IIASA) and studies as part of the Intergovernmental Panel on Climate Change (IPCC).

Though at this time we have examined supply technologies,[2] the study has indicated a number of important trends in energy systems. The work used a model to examine a range of alternative developments of future energy technologies to assess the ranges and distribution of investment costs. Rather than attempt to predict any one direction, the number of scenarios in which a given technology plays a meaningful role across a wide range of scenarios (34 in this study) is considered to be significant. The scenarios vary in environmental constraints, economic growth, population, energy consumption, the embedded energy infrastructure, local versus regional and regional versus global solutions.

It is worth keeping in mind that technology can change either incrementally or in a sudden jump. An example of a sudden change in energy technologies might be a scientific breakthrough that makes electricity from nuclear fusion a reality. But generally technology change takes place gradually, especially in energy systems, and small changes accumulate over time to produce large effects. The performance of a technology usually increases over time and costs are generally reduced along with environmental effects.

Because electricity-generation technologies are responsible for such a large part of energy consumption and are growing worldwide in step with economic growth, the portended changes in this sector are of great interest. Figure 1 shows the deployment of fossil electricity generation technologies during the 21st century across a range of scenarios. Not surprisingly, the relative roles of traditional electricity-generating technologies, such as conventional coal power, decrease consistently across all scenarios. At the same time, the roles of advanced technologies such as fuel cells, gas and coal combined cycles with carbon removal become more important over time.

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[2] ***An Assessment of Technological Change Across Selected Energy Scenarios***, N. Nakicenovic and K. Riahi, World Energy Council, London and International Institute for Applied Systems Analysis, Laxenburg, Austria, 2001

Advanced nuclear, solar photovoltaic conversion, and wind power also increase their contribution in this time period.

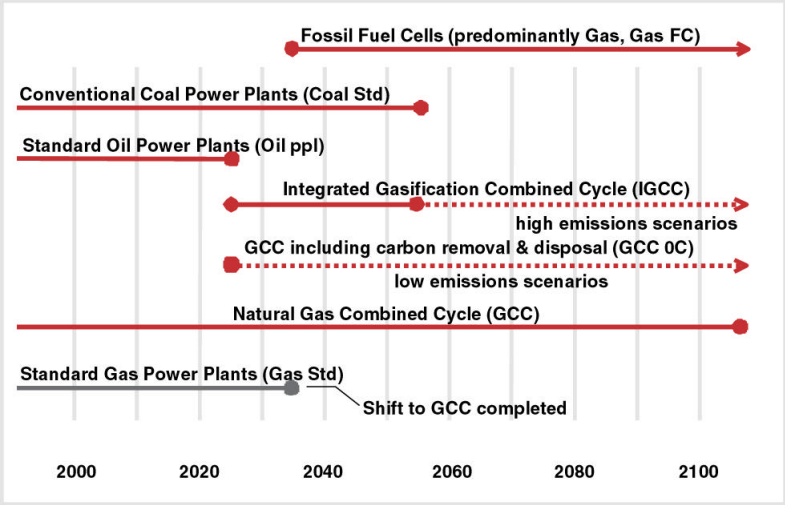

Figure 1. Deployment of fossil-fuel, electricity-generation technologies during the 21st century.[2]

These changes do not appear to take place in a meaningful way before 2020 due to the rigidities of the system, in particular the embedded infrastructure which, in most cases, is still being paid for. Before 2020, standard coal, integrated coal gasification combined cycle, natural gas and natural gas-combined cycle, and conventional nuclear and hydropower are major contributors to electrical generation. However, during this time frame, development continues on natural gas combined cycle with carbon separation and sequestration, and fuel cells such that, by 2050, replacement of much of the current global, as well as new, systems is by these technologies.

It is interesting to note that investment costs in electrical-generation technologies are predicted to decrease most rapidly for solar photovoltaic power, from clearly the most expensive today, to being competitive by 2050. Natural gas combined cycle, however, maintains the position of lowest investment cost.

The production of synthetic liquids is found by 2020 to be shared almost equally by methanol from coal and natural gas and by ethanol from biomass (Figure 2).

If coal is still a large source of energy in 2050, it would be the dominant source for liquids (Figure 3). However, in less coal intensive (carbon constrained) scenarios, biomass liquids predominate, much as one might expect. Not surprisingly, hydrogen produced from natural gas is important early in the century, although by 2050 hydrogen from natural gas increases by five-fold in the highest scenarios and two and one-half times for the median of all scenarios. Hydrogen from nuclear and solar produced electricity, while increasing its market share, does not become dominant until after this time frame.

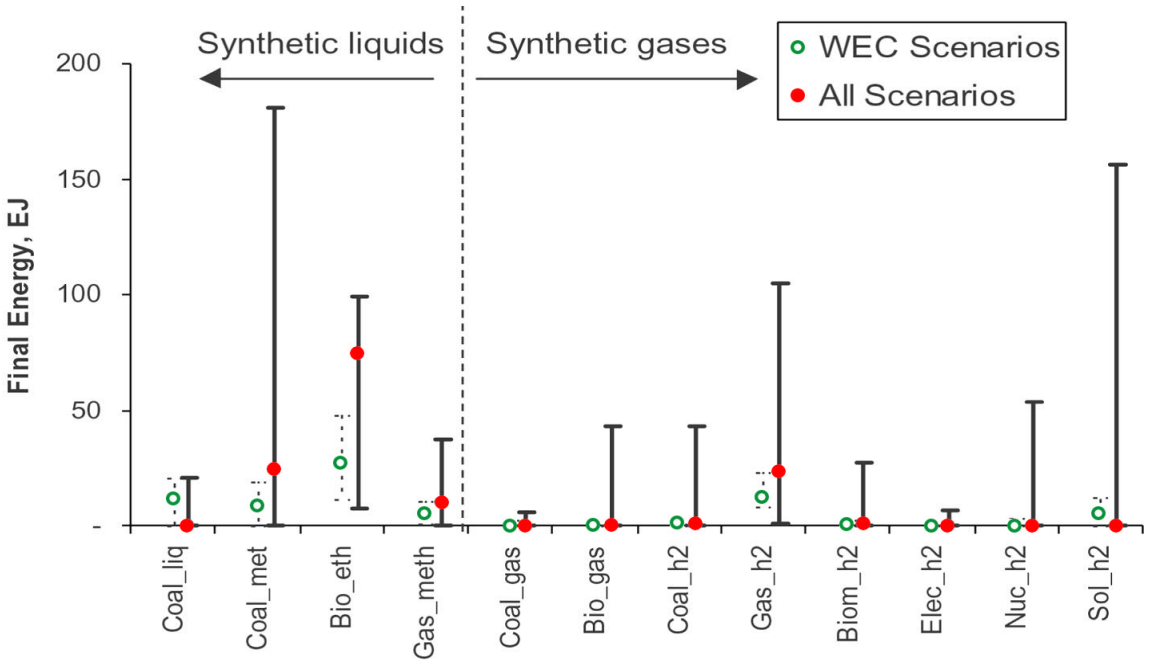

Figure 2. Synthetic liquid and gas production from various technologies across scenarios for 2020[2] Circle is the median value for each technology.

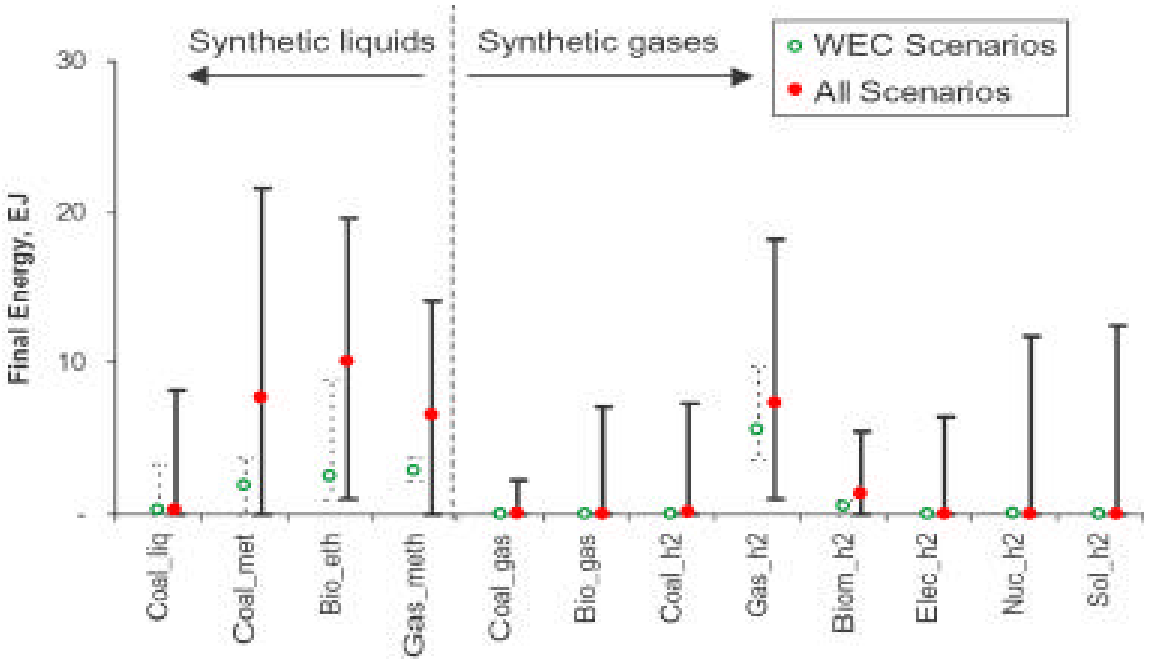

Figure 3. Synthetic liquid and gas production for various technologies across scenarios for 2050.[2]

Nearly all of the global transportation needs are met today by oil and its derivatives and this will not change before 2020. In all scenarios, the role of oil decreases while the synthetic fuels alcohol and hydrogen become more important. While oil is still the most important fuel in 2050 (Figure 4) and has increased its volume share as the market increases, its market share for transportation fuels will decrease. Natural gas, ethanol, methanol, electricity, and hydrogen are all important contributors by then.

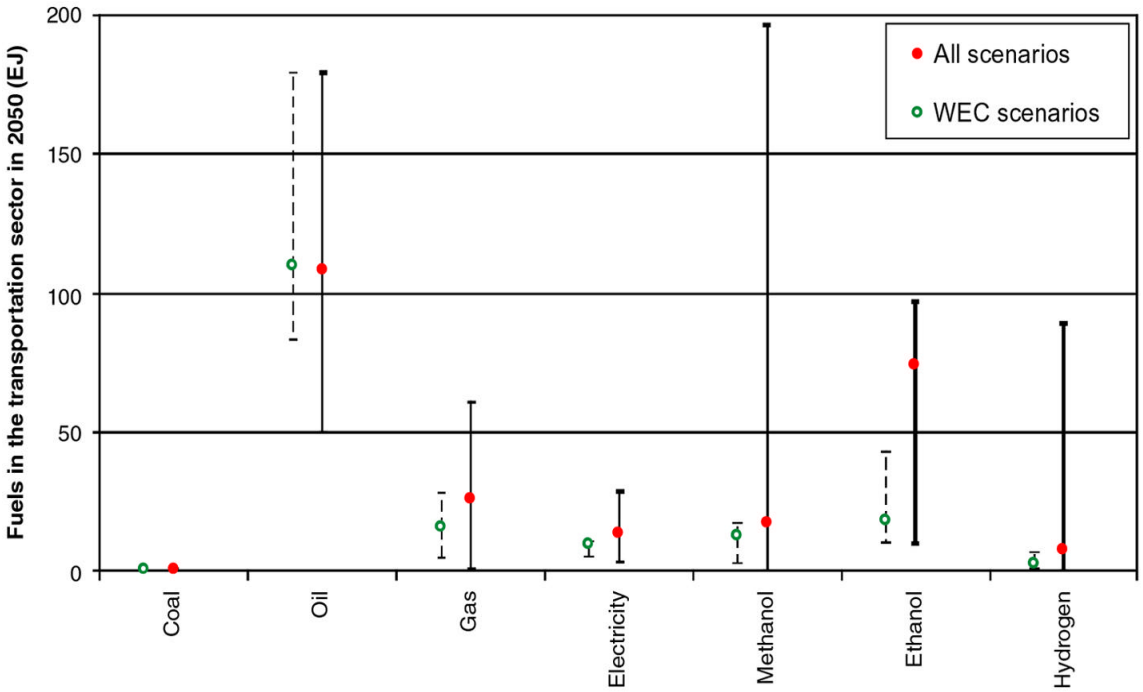

Figure 4. Transportation fuel utilization in 2050.[2]

A major conclusion we draw from this work is that the development of a range of these technologies, starting now, seems to be the best way to deal with the uncertainties of the future. In other words, these technologies appear to be robust against these uncertainties.

The continuation of this study will complement and build on the work done to date. Specific end-use technologies and the timing and possible costs of necessary RD&D need to be examined. In addition, the strategies of private industry should be studied. Finally, we will attempt to better understand the role that governments play in terms of funding and in terms of regulations (standards, administrative processes, litigation, etc.).